IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 22, Issue 2 Ser.5 (February. 2023), PP 43-55
www.iosrjournals.org

Ultrasound Evaluation of Lung Diseases In Infants.

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ABSTRACT:
Background*: The incidence of respiratory distress varies from 2 to 3.9% in developed countries, whereastheIndianstudiesreported anincidenceranging from0.69to 8.3%.*
This varies with gender, gestational age and bodyweight. Indian studies have reported aspiration pneumonia and bronchopneumoniaas leading causes of neonatal RDS and uniformly concluded that HMD is anuncommoncause ofRDS comparedtothe west.
The diagnosis and treatment of lung disorders in kids is a challenging issue forpaediatricians due to a wide variety of signs and symptoms. Conventional chest X-ray (CXR) plays a vital role in diagnosing respiratory diseases. But, the adverseeffectsof radiationexposure decreasesits applicationsamong kids.[1]
Recently, ultrasonography (USG) is increasingly used in various paediatricemergencydepartments, which is called lungultrasound (LUS)[2].
Materials and Methods*: This was a prospective, cross-sectional, interventional study done at a tertiary carehospital - NRI General Hospital, Guntur, Andhra Pradesh, India - equipped with allnecessaryfacilities.*
Interventionisintheformofestablishinganaccuratediagnosisthroughlungultrasound.
Results: *Mean age of presentation is 5.8 years. More common in male sex. Most common presentation being feeding difficulties and shortness of breath.*
Conclusion: *US is extremely helpful in assessing the diseases of lung, pleura, and mediastinum.Earlydetectionwith anopaquehemithorax isalso possible.*
Itmayhelpdeterminethecauseofmediastinalwidening,evaluateamediastinalmass if present, and rule out or confirm thymus as the cause of mediastinalwidening.Follow-up on ultrasound in neonates with RDS reduces the number of chestradiographs,thus reducing the radiationdose.
Key Word*: ultrasound, lung pathologies, pediatrics, most common age, most common presentation, low radiation dose.*

Date of Submission: 25-01-2023 Date of Acceptance: 08-02-2023

I. INTRODUCTION

In developed countries, the prevalence of respiratory distress ranges from 2 to 3.9%, whereas the incidence in Indian studies ranged from 0.69 to 8.3%.

This is dependent on gender, gestational age, and body weight. According to Indian studies, aspiration pneumonia and bronchopneumonia are the leading causes of neonatal RDS, and HMD is an uncommon cause of RDS in comparison to the west.

Because of the wide range of signs and symptoms, diagnosing and treating lung disorders in children is a difficult task for paediatricians. The traditional chest X-ray (CXR) is essential in the diagnosis of respiratory diseases. However, the negative effects of radiation exposure limit its use among children. Ultrasonography (USG), also known as lung ultrasound (LUS), is increasingly being used in various paediatric emergency departments.

Advantages of LUS:

- LUS is a quick and portable procedure.
- It does not emit ionising radiation and can produce reproducible results.
- Can be used in both inpatient and outpatient settings, in both acute and chronic conditions.
- Because infants have thin chests and smaller lung volumes, this process is an excellent diagnostic tool.
- Located in less accessible rural areas and/or developing countries.

- As a result, point-of-care ultrasound is increasingly being used in middle- and low-income countries to study organs other than the lung.
- LUS can only detect lesions that reach the pleura directly, with no normally aerated lung between the pleura and the lesion.

LUS has the following limitations:
- LUS is an operator-dependent procedure
- Accurate results are obtained with experienced operators who have received pulmonary ultrasound training.
- The main impediment to LU implementation is a lack of efficient and appealing training solutions. This is especially important for hospitals.

Researchfacilities:
The current research was carried out at the NRI Medical College attached to atertiary care hospital to evaluate lung diseases in neonates and infants using high-resolutionUSG.
Adequate facilities are available in the department of radiology and around 5 infantswerereferred with various lung disordersforUSG.

II. AIMS ANDOBJECTIVESOFTHESTUDY

Aim:
To evaluate lung diseases in neonates and infants using high-resolutionultrasonographytopreventradiationtothesepatientsinfuture.

Objectives:
1. TodetectchestdiseasesonUSGwhichareseenonchestradiograph.
2. Toevaluatethecauses ofrespiratorydistressinneonates.
3. Tostudythecharacteristicfeaturesofdifferentcauses.

III. MATERIALS&METHODS

MATERIALS&METHODS
Methodology:

This research was conducted after getting approval from the Institutional EthicsCommittee(IEC)oftheNRI MedicalCollege on 100 infants.
Initially,theinfantswereexaminedbyapaediatricianwhosemotherscamewithcertaincomplaints.
Infants were then referred to the radiology department to get a chest x-ray and USGwas done to check for the presence of lung disorders as a part of the research. Noinfantwas referred asa partofaroutine check-up.
As per the inclusion and exclusion criteria, we have chosen 100 infants for our studyaftertakinginformedconsent fromtheirmothers orfathers.

Study type, duration,and place:
This was a prospective, cross-sectional, interventional study done at a tertiary carehospital - NRI General Hospital, Guntur, Andhra Pradesh, India - equipped with allnecessaryfacilities.
Interventionisintheformofestablishinganaccuratediagnosisthroughlungultrasound.

Samplesize:
Around128kidswerereferredtotheRadiodiagnosisdept.ofNRIMCwhohadlungdisorders,requiringUSGfor diagnosisduringthestudyperiod.After considering the exclusion criteria, 22 kids were excluded from the study. 6parentsdidn'tprovideinformedconsent.So,wehaveincluded100infantsinourstudy.

Durationofthestudy: 1yearand10months: January2020toOctober2021.
InclusionCriteria
- Infants with clinical symptoms of respiratory distress and clinical suspicion of lungdisease.

ExclusionCriteria
- Childrenofagemorethan1 year
- Cardiovasculardiseasesandmediastinallesions
- Surgicalemphysema
- Post-operativecases

- Severethoracicdeformity

Material:

Lung ultrasound was done using PHILIPS AFFINITY 50G machine with the lineartransducer of 4-12 MHz in the Radio-diagnosis department of NRI general hospital. Itisahigh-endUSGmachinefromPhilips.

Benefits:

Ultrasonography of the chest is a non-invasive, economical, safe, reproducible andless time-consumingmethod. Itcanhelpinbetterevaluationoflungdiseasesininfantswhencombinedwithconventionalradiography. Mainprinciplesoflungultrasoundinclude:

1. Gasandfluidshaveoppositelocationsinthethorax.Theymaygetmingledbypathologicprocesses, leading toartefacts.
2. Thelungis themostvoluminousorgan. Standardizedareascanbedefined.[40]
3. Allsignsarisefromthepleuralline.
4. Staticsignsaremainlyartefactual.
5. Thesignsarisingfrom thepleurallineareforemostdynamic.
6. Almost all acute life-threatening disorders about the pleural line, explaining thepotentialof lung ultrasound.

Artefacts:

Artefactscouldbeconsideredanobstacleinimaging.
As air blocks the USG beam, seeing a healthy lung is not practical. 3 routinely seenandusedartefactsin the LUSinclude lungsliding,A-lines, andB-lines.[41]

Lung Sliding refers to a to-and-fro movement of the visceral pleura in contactwith the parietal pleura and has been described as a shimmering of the pleural lineon2-Dimensional ultrasound[42].
A-linesarehyperechoic,horizontallinesproducedatregularintervalsfromthepleuralline, whicharecalledA-lines.
IfyouseeA-lines, itmeansthelungscontainair.

B-lines are vertical hyperechoic lines arising from the pleural line extending to thebottom of the screen without fading. They move synchronously with lung sliding anderase A-lines.
Blineshelpinquantifyingextravascularlungwater.

Complete clinicalworkupwasdoneforalltheinfants,whichinclude-:

- Adetailedhistory.
- Milestones
- Generalphysicalexamination
- Vitals
- Systemicexamination

Parameterscollected:

- Age
- Gender
- Symptoms
- Historyoflungdisordersinfamily
- FindingsofChestX-Ray
- Associatedcomorbidconditions

LUSfindings:

- Pleuraleffusion
- Consolidation
- Lungcollapse
- Pneumothorax
- Lungsliding
- Pleuralthickening
- Additionalfindings
- Congenitalpulmonarymalformations.

Ethicalconsiderations:

The permission from the Institutional ethical committee attached to NRIMC wastakenbefore conducting the study.
Everyparentorguardianwasexplainedthewholeprocessandadvantagesofthestudy.
After he/she accepts, an informed consent form was given in local language orparentunderstandablelanguageandtheparentwasaskedtosignitorputathumbimpression.
Thediagnosticprocedureforassessingstudyparametershadminimalinterference.The parents were told that their information was kept confidential. Parents wereinformedthattheirparticipationwaspurelyvoluntary andof freewill. Data were entered into MS- Excel and analysed by using SPSS software.Descriptivestatisticswererepresentedwithfrequenciesandpercentages.

IV. RESULTS

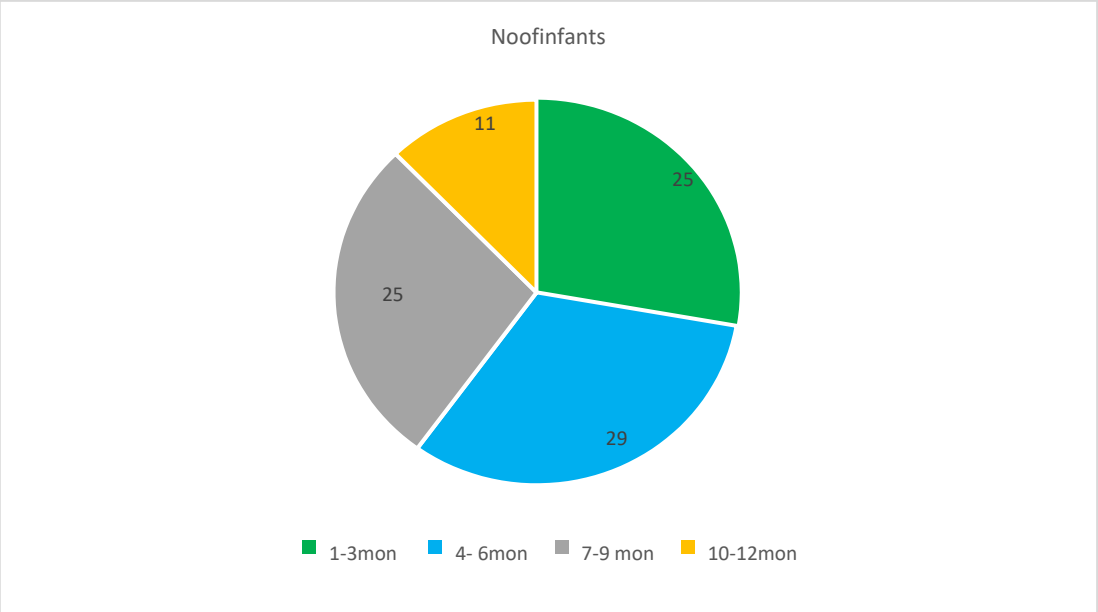
Statistical analysis was done using statistical software named Statistical Package fortheSocialScienceversion 20.0.0 (SPSSInc.,Chicago,Illinois, USA).
The categorical variables (qualitative data) like the presence of pleural effusion,consolidation, pleural thickening, pneumothorax, complaints and other findings areexpressedinpercentage.

Demographicvariables:
Ageof infants: The age of infants involved in this study ranged from 1-to 12 months. The mostcommon age of infants who presented with various lung disorders in our studyincludes-4to6months. Themeanageofinfants is5.87±2.98

Table1: Agedistributionofinfants

Age	Noof infants	Percentageofinfants
1-3months	25	25%
4-6months	29	29%
7-9months	25	25%
10-12months	11	11%

Graph1: Agedistributionofinfants

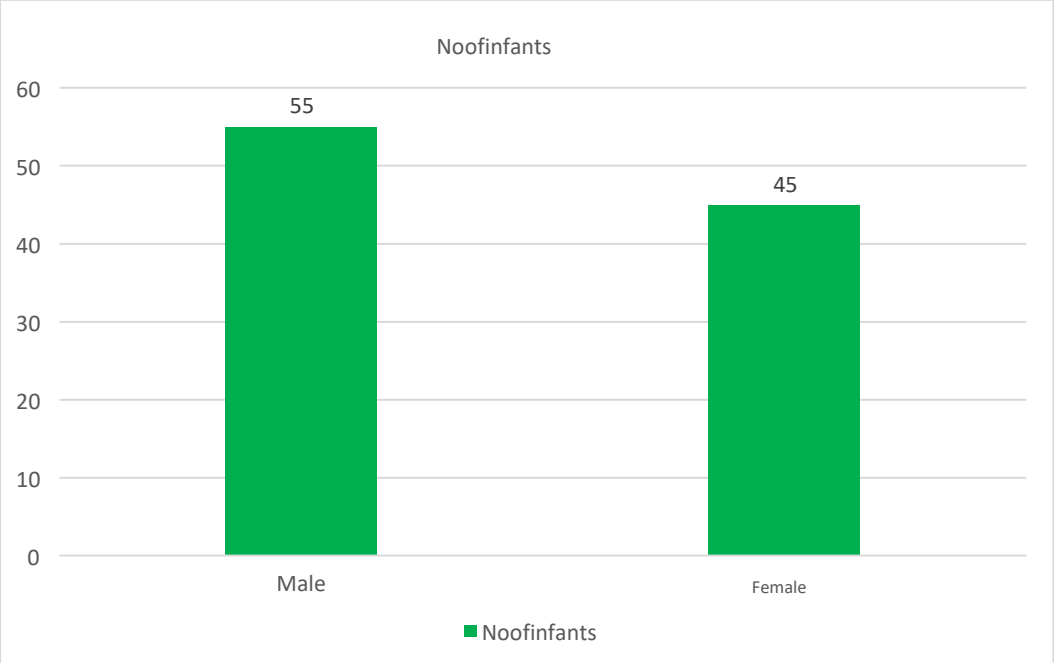


Gender of infants:
Inthecurrentstudy,55infantsaremaleand45arefemales,indicatingthatlungdisordersaremore common in male infants.

Table2: Genderdistribution

No ofMaleinfants	NoofFemaleinfants
55	45

Graph2: Genderdistributionofinfants



Complaints:
The following 3 complaints from infant's parents are the main cause of referral to theradiologydepartmentfor gettinga LUS

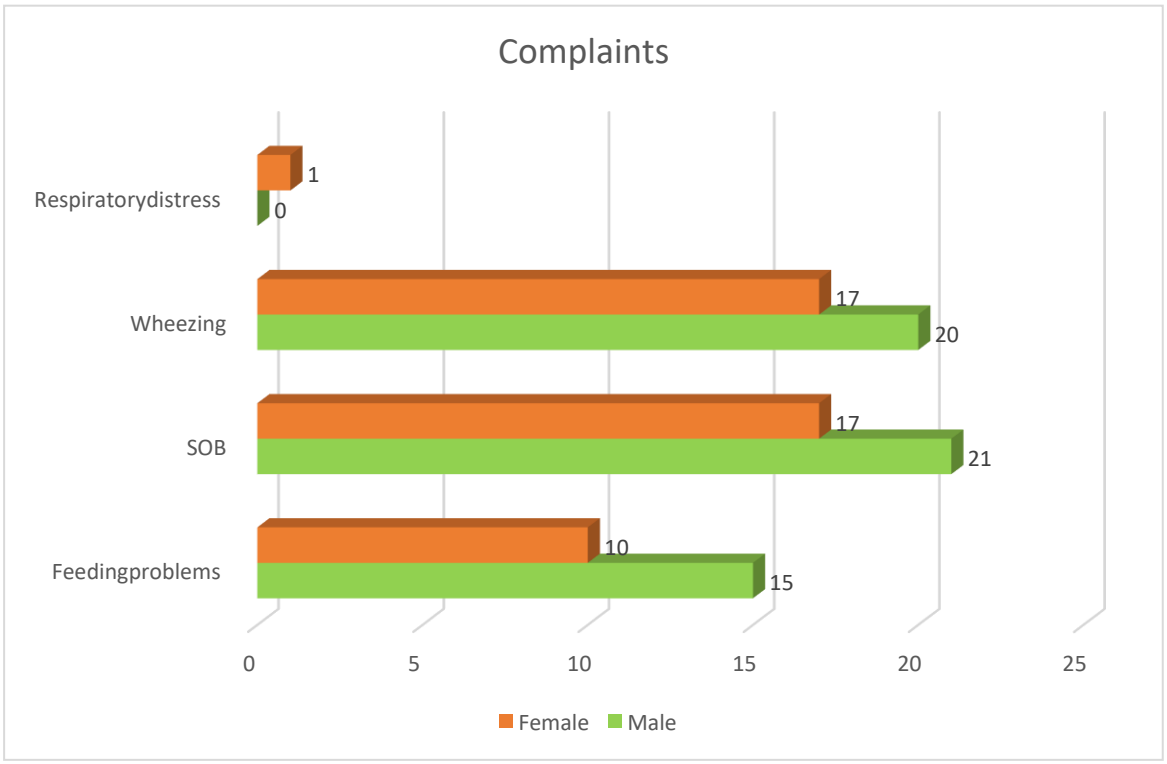
1. Feedingdifficulties
2. Shortnessofbreath
3. Wheezing.

Table3: Complaintsgivenbyinfant'sparents

PresenceofComplaint	**NoofMale infants**	**Noof Female infants**
Feedingdifficulties	15	10
Shortnessofbreath	21	17
Wheezing	20	17

Severerespiratorydistressisreportedinonefemaleinfant.

Graph3: Complaintsamonginfants

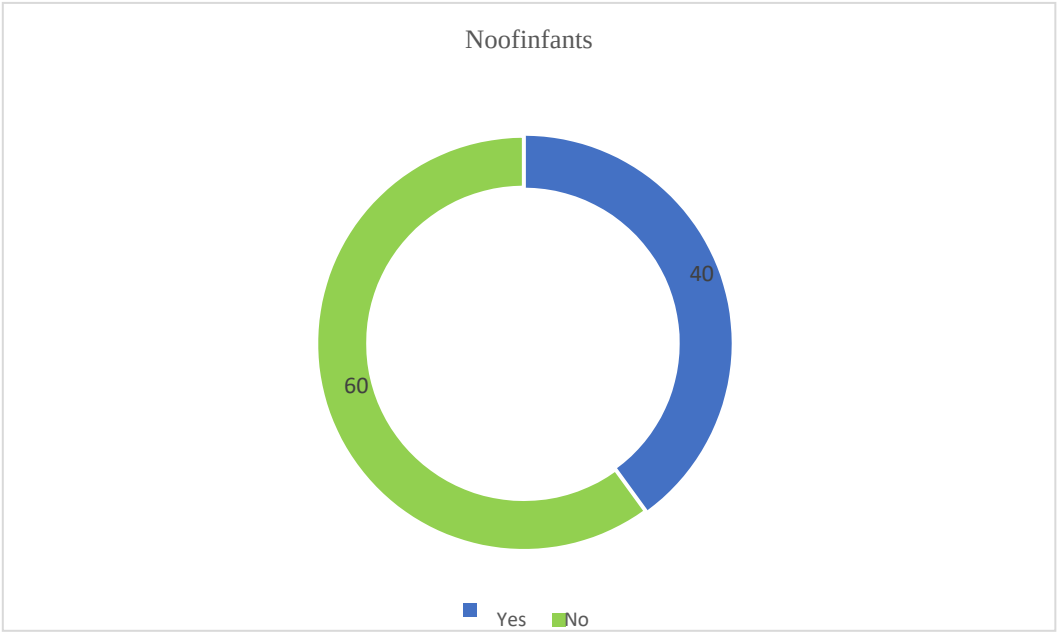


LUSFINDINGS:

Consolidation:

Consolidation is reported in 40 infants in our study. The presence of consolidationmayindicate infectiveetiology.

Graph4: Presenceorabsenceofconsolidationininfants



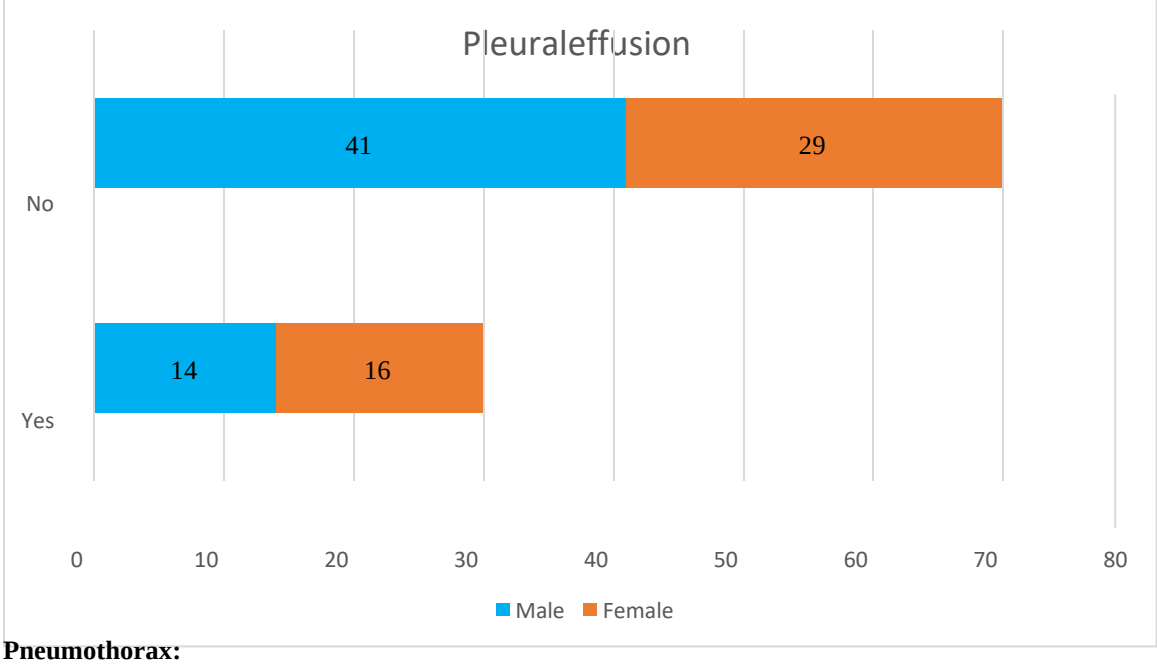
Pleuraleffusion:

30infantssufferedfrom pleuraleffusioninthecurrentstudy.Allthese30infantsalsohad associated consolidation. It is found to be more common in female infantscomparedtomale infants.

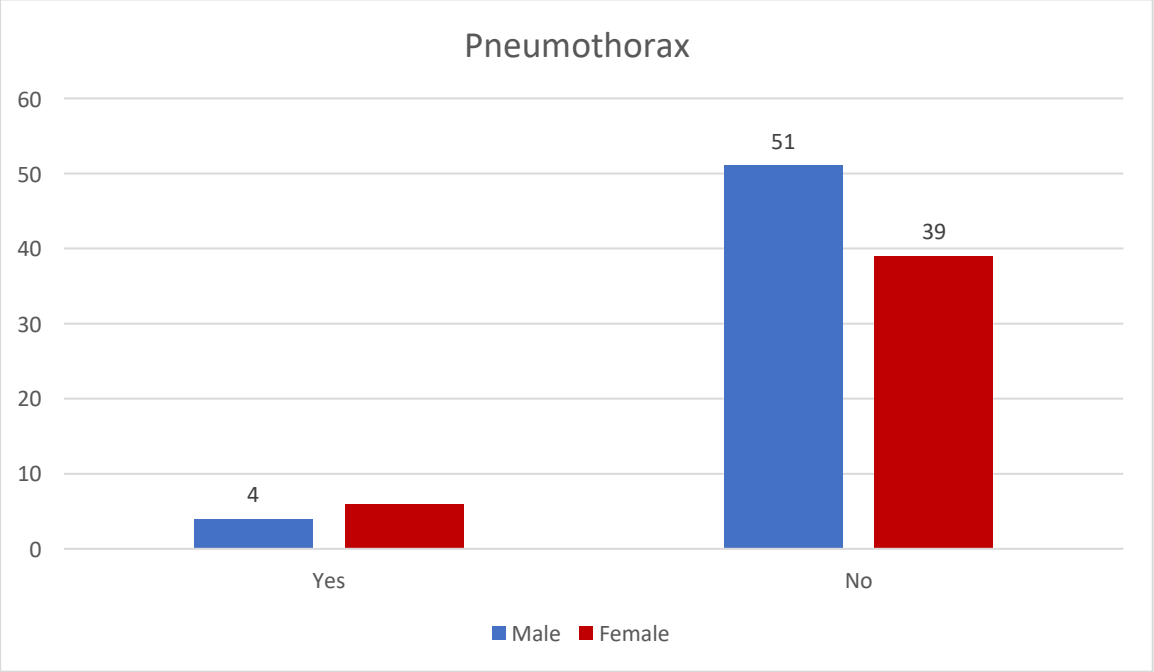
Table4: Pleuraleffusion-genderwiseamonginfants

Pleuraleffusion	Noofmaleinfants	Nooffemaleinfants
Yes	14	16
No	41	29

Graph5: Presenceorabsenceofpleuraleffusioninginfants



Pneumothorax:
Pneumothorax or the presence of air in between pleural layers is seen in 10 infantsin the current study. It is found to be more common in female infants compared tomaleinfants.

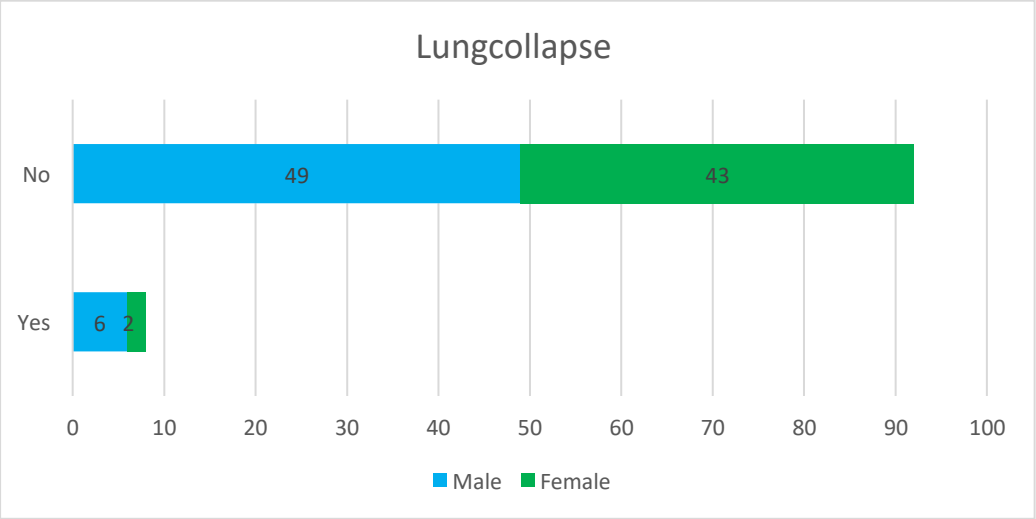


Graph5:Presenceorabsenceofpneumothoraxininfants

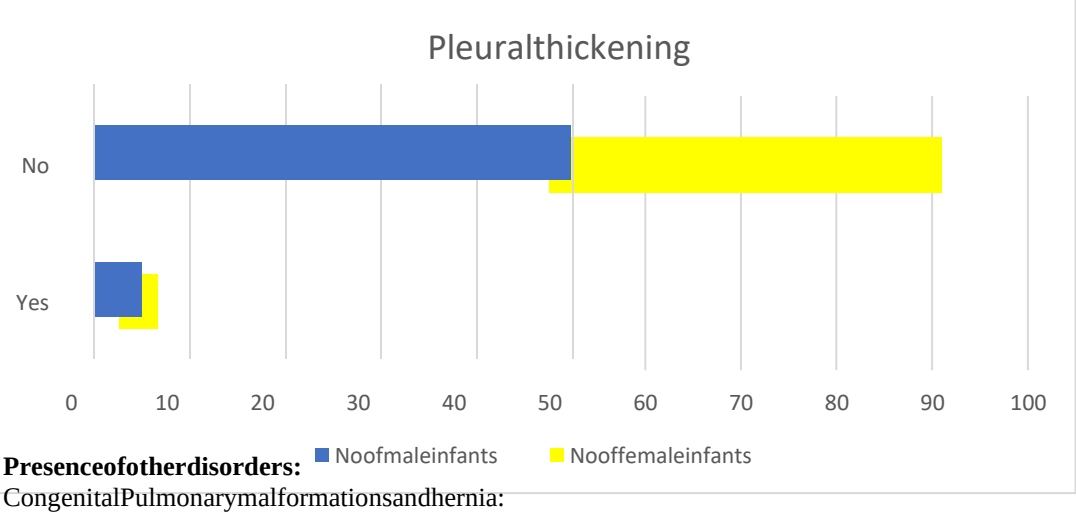
Lungsliding:
Lungslidingisabsentin10infantswhoaresufferingfrompneumothorax.Table5: Presenceoflung sliding amonginfants

Lungsliding	Maleinfants	Femaleinfants
Yes	4	6
No	51	39

Lungcollapse: Graph6:Lungcollapseamonginfants
Lung collapse or atelectasis is seen in 8 infants in the current study, indicating thatlungcollapseisrarecomparedtopleuraleffusionorconsolidationamonginfants.Itisfound to bemore commonamongmales Comparedtofemales.



Pleural thickening is seen in 9 infants- 4 female infants and 5 male infants.Graph7: Pleural thickeningamonginfants



Presenceofotherdisorders:
CongenitalPulmonarymalformationsandhernia:
2 infants are diagnosed with congenital pulmonary malformations and 2 infants hadcongenitaldiaphragmatic hernia.

Oxygensaturation:
Certain infants had a low oxygen saturation pertaining to the lung disorder. Most oftheinfants had asaturation level between 95to98%. Themeanoxygensaturationis95.42±3.0.Table6:Oxygensaturationamonginfants

Spo2levels	Noofmaleinfants	Nooffemaleinfants
98-100%	11	7
95-97%	28	20

90-94%	14	18
Below90%	2	0

Statistical analysis was carried out using the Statistical Package for the Social Sciences, version 20.0.0. (SPSS In c., Chicago, Illinois, USA).

The presence of pleural effusion, consolidation, pleural thickening, pneumothorax, complaints, and otherfindings are expressed as percentages for categorical variables (qualitative data).

V. DISCUSSION

Wehaveevaluatedultrasoundoflungsin100infantsinthecurrentstudy.
Variouscasesofconsolidation,atelectasis,pleuraleffusion,pneumothoraxandcongenitalmalformations have beendiagnosed.

A recent randomized trial[43] done on 40 kids found that general anesthesia-inducedatelectasis may be diagnosed with LUS and get better on time with the use ofpositive end-expiratory pressure. Atelectotrauma could be very harmful to theimmature, developing lung. Therefore, LUS may help provide lung-recruitingmanoeuvres sooner, especially in the most sensitive group of preterm infants withRDS.[44]

ComparisonwiththestudybyCattarossidoneon49neonates:

This study concluded that LUS has been found to have much better sensitivity,specificity, PPV and NPV compared to the chest X-ray in diagnosing various lungdisorders including pneumothorax. In our study, we didn't compare the results ofLUSwith CXR.Wedidn'tanalysesensitivity,specificity,PPVand NPV.

POC-US can help provide evacuation of pneumothorax evacuation and prevents thedevelopment of intraventricular hemorrhage that has a relatively well-establishedtemporal relationship to pneumothorax.[45] Two studies done on late-preterm and termneonates described LUS patterns. Researchers found that these patterns arereproduciblewithPPVof 100%andNPVof 97%.[46]

Also, in 130 premature infants on continuous positive airway pressure, the LUSscore correlated with all indices of oxygenation and proved to be accurate inpredictingthe needforsurfactant administration.

Lichtenstein's study[47]: This is a prospective study involving 32 patients with ARDS.Pleural effusion, alveolar consolidation, and alveolar-interstitial syndrome were seeninthese patients.

Auscultation had a diagnostic accuracy of 61% for pleural effusion, 36% for alveolarconsolidation, and 55% for alveolar-interstitial syndrome. CXR had a diagnosticaccuracy of 47% for pleural effusion, 75% for alveolar consolidation, and 72% foralveolar-interstitialsyndrome.

LUS had a diagnostic accuracy of 93% for pleural effusion, 97% for alveolarconsolidation,and 95%for alveolar-interstitial syndrome.

LUSalsohelpedtoquantifytheextentoflunginjury.

Rankin's study [48]: In this study, congenital diaphragmatic hernia was diagnosedusing LUS in a 12-day-old infant who presented with respiratory distress. On theaffected side, lung sliding was present only in the upper one-third of the chest withobvious intestinal peristalsis and loops of bowel visualized in the lower part of thechest.

Inourstudy,2infantswerediagnosedwithcongenitaldiaphragmatichernia.

Comparisonwiththestudybywen chen[49]:

This study was done to evaluate the usefulness of LUS in the neonatal intensivecare unit (NICU) on 3405 neonates. 2658 neonates had lung disease and 747-21%of infants had no lung disease. In our study also, 21 infants -21% had no lungdisease.

Thefollowing signswere seenonLUS:

- AbsenceofA-lines
- Pleural-lineabnormalities
- Interstitialsyndrome
- Lungconsolidation
- Airbronchograms
- Pulmonaryedema

81casesthatarenotdiagnosedintheCXRgotidentifiedaspneumonia,RDSorTTN on LUS. This indicates high sensitivity of LUS over CXR. And, 23 casesmisdiagnosedas RDSby CR werediagnosedas TTN onLUS.

Of 747 cases without lung disease, B-lines of 713 neonates were found within 3 daysafterbirth.
In our study, we found consolidation and pleural effusion as common LUS findings.And,we didn'tevaluateBlinesin ourstudy.

Lung Ultrasound for diagnosing NRDS meta-analysis[51]: This meta-analysisassessedthediagnosticvalueofLUSinthediagnosisofNRDS.Resultsshowedthat LUS provided a pooled sensitivity of 0.92, specificity of 0.95. The findingsdemonstratethat LUShasahighdiagnostic value for NRDS.

Benefitsandstrengthsofthepresentstudy:
- Knowing the accurate diagnostic method to identify lung disorders in infantscouldhelptakeappropriatestepstomanagetheseontime.
- Studies with fewer subjects 100 like the present study were quick to conduct ashortdurationoftime is needed.
- Easytoreviewinfants'caserecordformsatanytime.

Theeconomicbenefit:
- Physical examination, systemic examination, vitals were analysed freeofcostfor allthesubjects involvedin thestudy.
- Apartoftravelexpensesforpatientshasbeenreimbursed.

- A part of the expenses incurred for the LUS was reimbursed to all theinfant'sparents.
- Part of the expenses incurred for the treatment of diagnosed lungdisorders wasreimbursedto alltheparents.
- Tests like CXR, CT chest which are required for a few infants weredonefreeof cost.

Limitationsofthe currentstudy:
- ✓ Inthisstudy,thesamplesizewas100,indicatingthatthestudysamplewassmall,andtheprimarylimitationwasth e interpretationof results.
- ✓ Results for small studies were less reliable compared to larger studies. Largerstudies with more subjects produce narrow confidence intervals (95% to 99%)andproducemoreaccurateresults.
- ✓ Thestudywasdoneonpatientsagedbelowoneyearonly.

- ✓ Infantswerefollowed uptill 30daysofthediagnosisonly.

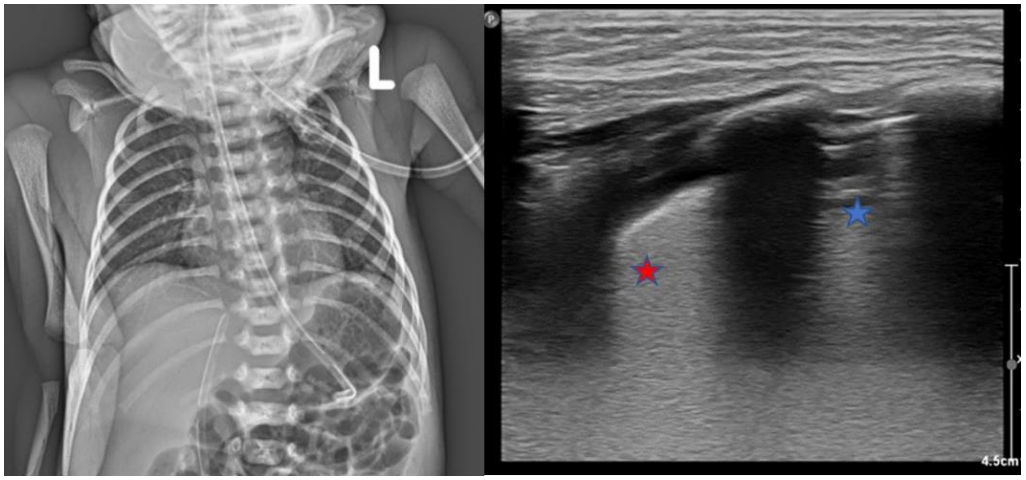
- ✓ Inter-observervariationsmaydecreasethereproducibilityofresults.

VI. SUMMARY&CONCLUSION

US is extremely helpful in assessing the diseases of lung, pleura, and mediastinum.Earlydetectionwith anopaquehemithorax isalso possible.
Itmayhelpdeterminethecauseofmediastinalwidening,evaluateamediastinalmass if present, and rule out or confirm thymus as the cause of mediastinalwidening.
Follow-up on ultrasound in neonates with RDS reduces the number of chestradiographs,thus reducing the radiationdose.
The research or the information available on the usage of LUS in neonatalemergency care is still less compared to adult emergency care. So, more studiesshouldbedone inthisfield.
Based on the results of our study, we conclude that the ultrasound findingscombined with clinical information and chest x-ray are useful for the diagnosis ofneonatallungdiseases.
Inaddition,lungultrasoundisasafe,inexpensiveandeasytooperatetoolthatcanbe repeatedly and rapidly performed at the bedside without anesthetic drugs. Lungultrasound is worthy of clinical application and promotion, given all its advantages.Therearenoconflictsof interest andthestudyis self-sponsored.

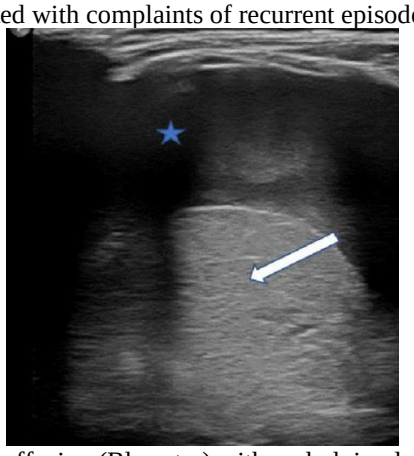
VII. REPRESENTATIVE CASES

Case 1: A 35+/-5d weeks old was born by C-section with respiratory distress. Clinical diagnosis – Transient Tachypnea of new born.
Chest Xray – normal lung.



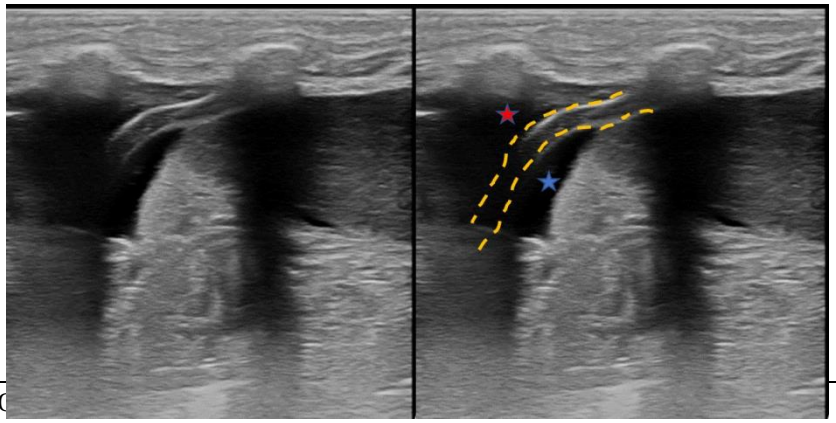
USG – Double lung point in the right lung. (Blue star – normal lung field with A lines; Red star – compact B lines with loss of A lines) – Suggestive of TTN in new born.

Case 2: 10 month old presented with complaints of recurrent episodes of fever and SOB.



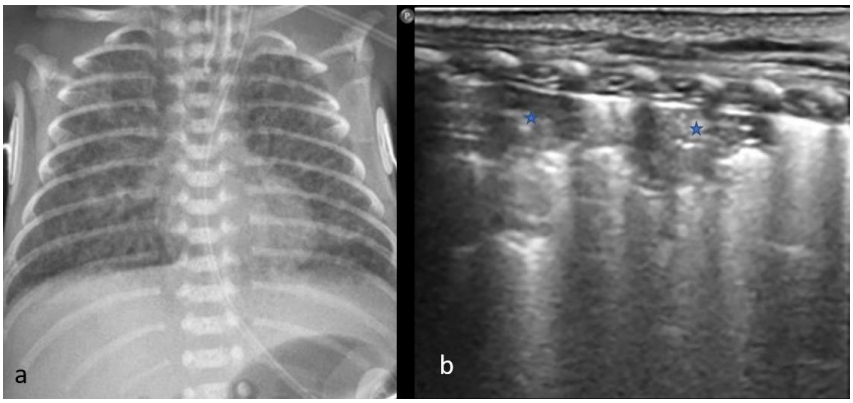
USG shows moderate pleural effusion (Blue star) with underlying lung collapse (arrow).
Collapsed lung appears isoechoic to lung – Hepatization of lung.

Case 3: A 2 month 3 weeks old infant presented with history of fever and jaundice for 4 days.
Chest X ray – Normal.Yellow dotted line – Diaphragm.
Minimal fluid below the dome – suggesting ascites (Blue star). Mild fluid above the dome indicating pleural



effusion(red star)

Case 4: A 33 week old premature infant with Respiratory distress from birth.



CXR: AP radiograph showing uniform coarse reticular opacities with generalized hyperaeration.

USG: Multiple small sub pleural consolidations (Blue star) with irregular B lines in both lungs – suggestive of Bronchopulmonary Dysplasia.

Case 5: A 3 week old neonate with pneumothorax.

USG-B lines are absent (Black arrow) with transition point showing compact B lines (White arrow) – Specific for pneumothorax.

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